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Nowikoff, M.

1907. Über die Rückensinnesorgane der Placophoren nebst einigen Bemerkungen über die Schale derselben. *Zeit. Wiss. Zool.*, Bd. 88, pp. 153-186.

1909. Über die Intrapigmentären Augen der Placophoren. *Ibid.*, Bd. 93, pp. 668-680.

Pelseeneer, P.

1906. Mollusca, in Lankester, Treatise on Zoology, Part V, 355 pp. London.

Plate, L.

1899. Die Anatomie und Phylogenie der Chitonen (Theil B). *Zool. Jahrb.*, Suppl., Bd. 4 (Fauna Chilensis, 1. Bd.), pp. 15-216.

1901. *Idem.* (Theil C). *Ibid.*, Bd. 5, pp. 508-600.

Sampson, L.

1895. The Musculature of *Chiton*. *Jour. Morph.*, Vol. 11, pp. 595-628.

THE BIONOMICS OF PORICHTHYS NOTATUS GIRARD

Porichthys notatus is a batrachoidid fish, which is known to range from southern Alaska to the Gulf of California, and from depths of at least 62 fathoms to just above the lower low-water level of the reefs. During the fall and winter months it inhabits comparatively deep water, where nothing definite is known concerning its life, beyond the fact, recorded by Dr. and Mrs. Eigenmann (1889, p. 132), that it is at least occasionally preyed upon by rock-cods (*Sebastodes*). In the late spring and early summer a shoreward migration apparently takes place (Greene, 1899). Along the coasts of Lower California and on the mainland shore of southern California, it is usually found in shallow bays at this season; at Santa Catalina Island Holder (Holder and Jordan, 1909) has mentioned hearing numbers just off rocky shores. There is but one record of the occurrence of the species in the reef-pools south of the vicinity of Pt. Conception in California, Hilton (1914) having found a specimen in a pool on the reef at Laguna Beach, California.

From Pt. Conception northward, on the contrary, this species, while never abundant is by no means rare along the reefs within tidal limits, during the breeding season. Here it occupies very shallow, often sandy pools, either those containing boulders or those with horizontal crevices in the rocky sides. It is here a fish of sluggish and retiring habits, swimming slowly with an undulating motion; when disturbed it usually seeks shelter, but sometimes swims off a short distance only, coming to rest and

partially covering itself with sand by a lateral twisting of the body. It is able, by a sudden movement of the body, to inflict a rather painful wound with the opercular spine.

The stomachs of the specimens examined from reef-pools were mostly empty; one contained some sand and an empty snail shell, while another had eaten a crab (*Petrolisthes*), of a species which abounds beneath stones along the fore-shore. Eigenmann (1892) found an anchovy in the stomach of a *Porichthys* from San Diego Bay, and the writer found a sardine (*Sardinia caerulea*) in the stomach of a specimen from San Diego County.

The adult is dull brownish, varying very little in color and not much in shade. The photophores are evident as silvery spots, due to the reflection of external light. There is a whitish translucent spot below the eye, and another behind the pectoral fin, in the position of a large pore in *Batrachus tau*. Owing perhaps to a greater development of black pigment, the males retain more of the dark pattern of the young than the females do. The coloration of specimens 26 mm. long was described in the field as follows. Eight greenish black bars extend from the mediodorsal line to the upper edge of a broad silvery stripe with metallic reflections, which occupies the middle third of the body. The fins are clear, excepting a basal caudal bar, and the two dorsal spines. The head is mottled with dark above, and is silvery on the sides and clear below, excepting the dark ring surrounding each photophore. A conspicuous narrow black streak, located below the eye, branches once or twice posteriorly.

Parental care is generally practised in the Batrachoididæ. *Porichthys notatus*, as noted above, after migrating shoreward during the late spring and early summer, breeds in shallow water, within tidal limits from the region of Pt. Conception northward, where all of the following observations were made. No details of the breeding habits prior to the guarding of the eggs have heretofore been published. Males with enlarged testes were taken by the writer on several occasions from June 2 to June 15, in no case guarding eggs, and in one instance, on June 20, one was found in company with a female containing matured eggs. A male with ripe testes was found washed up on the beach near the reef of Government Pt., near Pt. Conception, on July 15. The females must leave the pools as soon as, or soon after, the eggs are laid, as none other than the one just mentioned was observed in the tidal zone. As Greene (1899) has already remarked, it is the males which guard the eggs and

young, remaining within a few feet of them even when disturbed. The eggs are cemented to the roof overlying a shallow crevice in the rocks or a space beneath a flat boulder. They somewhat suggest the familiar egg of the Pacific salmon in color, and vary in the larger diameter from 4.0 to 6.0 mm. They are slightly compressed, as though by pressure against the rock, and are broadly elliptical in outline.

The young hatch out during the summer. Jordan and Starks (1895, p. 840), in discussing the species as found in Puget Sound, remark "the young fasten themselves to the rocks by means of a ventral disc which soon disappears." They mention further that "the adult remains with the young until they are quite well matured." On October 25 the writer found a single grunting male under a large flat stone in a pool about two feet square, with numerous young all about 26 mm. long. Other young, 22 to 28 mm. long, were caught in a larger pool on October 26. None has been obtained on the reefs in the winter or spring; young as small as 23 mm. have been taken by the Scripps Institution for Biological Research, at La Jolla in depths as great as forty fathoms. Except for their proximity to the eggs, the males show no special habits which might be construed as definitely protective.

Porichthys is one of three genera of phosphorescent shore-fishes, the other two being *Anomalops* and *Photoblepharon* of the East Indian reefs. In each of these East Indian fishes the single large light-producing structure is located below the eye (Steeche, 1909), while in *Porichthys* a large number of photophores (in *P. notatus* Greene found an average of about 700) are developed in connection with the several lateral lines (except the uppermost, which is only rarely accompanied by a few rudimentary light organs), one photophore being opposite each pore. The photophores are most abundantly developed on the ventral surface, and all are oriented downward. The same condition holds true in the several other diverse groups of fishes, mostly pelagic or bathypelagic, in which the power to emit light has obviously been independently acquired, as well as in certain other phosphorescent animals, such as the bathybial cephalopods. This general downward cast of the light of luminescent marine animals, a point regarded by the writer as of critical significance, has apparently not been duly considered by any of the authors who have proposed such varied theories to explain the biological significance of biophotogenesis.

The histology of the photophores of *Porichthys notatus* has been reported upon in detail by Greene (1899), and ten years earlier by Eigenmann and Eigenmann (1889), and by Test (1889). These organs were found by the writer to be completely and typically developed in young about 25 mm. long (sectioned at Stanford University). Each photophore lies deeply imbedded in the dermis. It consists essentially of a more or less parabolic reflector surrounded by a mass of melanophores, and enclosing the photogenic gland cells, which are richly supplied with blood vessels, but according to Greene not specifically enervated. The light passes downward either directly from these cells, or indirectly from the reflector, through the large lens and the cornea-like epidermal covering of the organ. The ventral aspect of the illuminated fish is striking, the hundreds of dots of light being arranged in a symmetrical pattern.

The light of *Porichthys* has been observed only in the laboratory, where it has been produced as a response to intense electrical or chemical stimulus. Green records but one instance of a slight glow of the photophores being produced by mechanical stimulus. In experimenting with two specimens from rather deep-water, the same author was unable to produce any reaction of the photophores, although he applied stimuli successful in the case of individuals from the reefs. This observation, while of course insufficient, perhaps indicates that the luminescence may be characteristic of the breeding season. In this connection it is also significant to note that Holder's observations (Holder and Jordan, 1909) indicate that the species is of nocturnal habits, its grunting being heard chiefly at night, or in the evening or early morning.

The peculiar humming sound produced by this species during the night, or during the day when disturbed, is another of its remarkable characteristics. The sound (which by some has been called a "song," an expression which seems quite figurative) is produced in the air-bladder, which has a very thick muscular wall, and is enervated by the thickest ramus of each vagus nerve. Upon opening a live specimen the air-bladder was observed by the writer to vibrate rapidly while the fish was grunting, and the sides of the body were felt vibrating at the same time. The abdomen of young about 25 mm. long was also felt vibrating, but the sound produced, if any, was inaudible.

BIBLIOGRAPHY

Eigenmann, Carl H.

1892. The Fishes of San Diego, California. *Proc. U. S. Nat. Mus.*, Vol. 15, pp. 122-178.

Eigenmann, Carl H., and Eigenmann, Rosa Smith.

1889. On the Phosphorescent Spots of *Porichthys margaritatus*. *West Am. Sci.*, Vol. 6, pp. 32-34 (see also p. 132).

Girard, Charles.

1858. General Report on the Fishes. U. S. Pac. R. R. Surv., Vol. 10, Pt. 4 (p. 134, pl. 25).

Greene, Charles Wilson.

1899. The Phosphorescent Organs in the Toad Fish, *Porichthys notatus* Girard. *Jour. Morph.*, Vol. 15, pp. 667-696, pls. 38-40 (reprinted as: Contr. Biol. Hopkins Seaside Lab., No. 18, 1899).

H[il]ton, W. A.

1914. Record of Two Fishes not before Mentioned, from Laguna. *Jour. Ento. and Zool.*, Vol. 6, p. 233.

Holder, Charles Frederick, and Jordan, David Starr.

1909. Fish Stories (New York) (pp. 315-318).

Jordan, David Starr.

1905. Guide to the Study of Fishes (Holt & Co.), 2 Vols. (Vol. 1, pp. 190-197, Figs. 146-148; Vol. 2, p. 526, Fig. 481).

Jordan, David Starr, and Evermann, Barton Warren.

1896. The Fishes of North and Middle America. *Bull. U. S. Nat. Mus.*, No. 47 (Pt. 3, pp. 2321-2322).

Jordan, David S., and Gilbert, Charles H.

1881. Notes on the Fishes of the Pacific Coast of the United States. *Proc. U. S. Nat. Mus.*, Vol. 4, pp. 29-70 (p. 65).

1883. Synopsis of the Fishes of North America. *Bull. U. S. Nat. Mus.*, No. 16 (pp. 751-752).

Jordan, David Starr, and Starks, Edwin Chapin.

1895. The Fishes of Puget Sound, *Proc. Cal. Acad. Sci.*, Ser. 2, Vol. 5, pp. 785-855.

Prince, E. E.

1910. [Discussion of Gill's paper on the habits of fishes.] *Bull. U. S. Bur. Fish.*, Vol. 28, pp. 1068-1069.

Steche, Otto.

1909. Die Leuchtorgane von *Anomalops katoptron* und *Photoblepharon palpebratus*, zwei Oberflächenfischen aus dem malaisischen Archipel. Ein Beitrag zur Morphologie und Physiologie der Leuchtorgane der Fische. *Zeitschr. Wiss. Zool.*, Vol. 93, pp. 349-408, 3 pls., 5 figs.

Test, Frederick C.

1889. New Phosphorescent Organs in *Porichthys*. *Bull. Essex Inst.*, Vol. 21, pp. 43-52, pl. 4.

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